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## THE CHEMICAL COMPOSITIONS OF CERTAIN OHIO AND PENNSYLVANIA COALS AS COMPARED WITH THEIR EVAPORATIVE PERFORMANCE IN LOCOMOTIVE BOILERS.

BY PROF. N. W. LORD.

While numerous analyses of Ohio coals have been made and published, but little work has been done to compare in any way the real performance of the various seams in actual work, or to show whether such performance could be predicted from the analysis as ordinarily made. The reason is in all probability to be found in the great difficulty which surrounds any such investigation.

The use of coal for making steam being of such great importance more knowledge of the evaporative performance of well known coals would seem very desirable but at the outset of such an investigation one is met by the fact that the utilization of coal in boilers is very imperfect, in fact but a portion of the heating power is realized in the best grade of work and as ordinarily used, the test of the evaporation obtained from a given coal is more likely to be a measure of the inefficiency of the boiler, furnace and fireman than of the grade of the coal, and even when all precautions are taken to insure the best and most perfect combustion with the least practicable excess of air to take the heat up the chimney, still the test would only show the relative value of the coals for the particular grate, boiler and furnace using them. Still such tests have great value to the concern making them and are now made more and more by large consumers. The price to be paid for coal will depend upon the results, A coal which will evaporate eight pounds of water per pound is obviously worth more per ton than one that will evaporate but six pounds. If they can be purchased at less than that difference per ton the economy of sometimes buying the high priced fuel is very apparent.

This is most strikingly true if freight is added as an element in the cost of the coal to the consumer, for in that case he pays proportionately and the freight on his six pound coal will be one-

third more per unit of value than on the eight pound coal. In fact it is known to all that only the best fuel will bear long transportation.

Through the kindness of one of the largest consumers of coal in Ohio, I am able to present this Institute with the results of the tests in locomotive boilers of several important Ohio and Pennsylvania coals. These tests were made by careful weighing of the coal supplied to the locomotive, also measuring the water used and taking its temperature. Each test is the average of three trials, none differing more than four-tenths of a pound. The whole time consumed in the comparison extended over several weeks. At the same time that the trials were made, large samples were carefully taken, boxed up and sent to the University laboratory where I had the analysis made. The samples sent me were from 50 to 100 pounds. They were crushed, mixed and carefully reduced to the small samples used in the analysis. I give the tabulated results of the work. Both the proximate and the ultimate analysis were made and I give also the computed heating powers by the formula.

Heating Power =  $34560 (H - \frac{1}{8} O) + 8080 C + 2220 S - 589 (\frac{1}{8} O)$

The "Fuel Ratio" is also given. This is the result obtained by dividing the "Fixed Carbon" by the volatile combustible matter, and is used in comparing coals in the Reports of the Pennsylvania Geological Survey.

For obvious reasons the names of the owners of mines are suppressed, as well as all other matter of private and business nature.

A consideration of the table shows at once, 1st, the very small percentage of the theoretical evaporating power realized. 2nd, that there is little or no correspondence between the analytical results and the practical evaporation obtained. It is evident that while as a general statement it is true that a higher heating power implies a higher evaporative power, there is no direct relation and that here is nothing like the differences in the composition of the coals that would be needed to explain the results shown in practice. What then must we look to to explain the differences? For the differences in effect are there and control the use of the coal. I can only charge it to the physical characters of the coal, the tenderness or hardness. The tendency to escape unburned and the tendency to decrepitate or split up and fall to powder, or some other difference in its physical nature which controls the relation of the coal to grate and draught.

The evaporative power obviously follows the seam closer than it does the analysis, which would again point to the influ-

ence of mechanical condition as determining the evaporative value. But look at the difference between coals Nos. 2 and 3, coals almost identical in their chemical character. I can only charge it to difference in mechanical condition.

In bringing these results before the Institute, I feel they are very unsatisfactory in character and offer them merely to show how far from satisfactory our knowledge of the qualities of the coal is, and that to rely upon an ordinary analysis to determine the steaming quality of coal is to trust to an illusion. Unless the conclusions from analysis are controlled by experience with the mechanical adaptability of the coal to the grate and furnace on which it is to be used.



Obviously the analysis of the coal as made from the samples I received is not an index of their value. I am inclined to charge these differences in the efficiencies of these coals to mechanical differences in the character of the coal, conditions entirely independent of composition so that the physical condition of the coal is a better index of what will be obtained from it in ordinary boiler practice, particularly in locomotive boilers, than the ultimate or approximate chemical analysis. As the mechanical nature of the coal simply means its adaptability to the kind, or boiler and grate in which it is used, I regard that these evaporating powers measure not the evaporating efficiency of the coal in any degree, but the correspondence between the furnace and the mechanical character of the coal; so that the calculation would show that these evaporative tests, while they are of great importance, may be misleading, because they simply show the correspondence between the mechanical condition of the coal, its mechanical character and the grate burning arrangement in which it is to be used. I submit these results as a puzzle, and I have given my opinion of the probable solution of the puzzle.

MR. ROY: I think that is a puzzle too, and the analysis don't help there at all.

PROF. LORD: Not at all, and the only explanation I can offer is that the evaporation power, as shown there, measures the adaptation of the physical character of the coal to the arrangement of the grate; but these figures are all facts.

MR. ROY: The coals behave differently in burning that are otherwise the same. Now there is something in that that I did not understand. I spoke in my paper yesterday of the limestone coal about holding fire well. I have seen no analysis of that coal, and I will send you some to have it analyzed; but I would judge comparing it with the Wellston coal that it would contain less water, more sulphur and about the same amount of carbon. In burning the Wellston, coal will burn up and make an intense heat, so intense that you are hardly able to stay in the room and burn out rapidly, while the other coal will last twice as long. It will emit the same heat, but the heat in one case will come out in half an hour, and in the others three quarters of an hour perhaps.

PROF. SPERR: It seems to me that something could be developed there. I thought at first I discovered a law there in

which there is only one exception which we would not be justified as admitting as an exception without further investigation, and that is that the presence of moisture had something to do with the evaporation power, and it occurred to me something like this: you have all no doubt noticed in practice that fireman sometimes throw water on their coal to make it burn better. Why do they do that? Possibly the mechanical action it would set up by moistening the coal would increase the evaporation power. That is it would break up the coal sooner and burn more rapidly. Has there been any investigation made, Prof. Lord, as to the evaporation power per hour of these different coals.

PROF. LORD: No, there has been no record kept of that. The idea was to determine which coal you could get the most work out of.

PROF. SPERR: Did you notice any difference in the samples?

PROF. LORD: The samples I received were broken up so that I could not observe them.

SECRETARY HASELTINE: Professor, if each coal was used in a grate that was the best adapted for its characteristics, would it change the results of its evaporating power as shown by your experiments in these papers.

PROF. LORD: I think it would very decidedly.

SECRETARY HASELTINE: Then I understand from this that each coal there was tested in exactly the same furnace, and no attention was paid to whether it required more or less air or more or less grate surface at all.

PROF. LORD: Not a bit.

SECRETARY HASELTINE: And it gives you this checkered result.

PROF. LORD: Yes sir. I bring the figures as I say a sort of puzzle. Now then this test was no small test. It was on a large scale, and I happened to know that it controlled the pur-

chase of coal by that company, and yet they did some coals great injustice.

SECRETARY HASELTINE: By reason of their not applying suitable grates for the burning of that character of coal.

PROF. LORD: Yes sir, it suits their conditions, because their grates are all alike.

SECRETARY HASELTINE: It is a fact that coal dealers are familiar with that, if you take Pittsburgh coal and fire it in a fire-box that has been adjusted for the burning of the Massillon dry burning coal that the Pittsburgh coal is at a great disadvantage, that it melts and runs together, and it has been known to be condemned as being inferior to the Massillon coal when there was no question but what the trouble arose from the adverse conditions under which the Pittsburgh coal was fired, because the Pittsburgh coal is undoubtedly a much richer and better coal and higher in heat qualities than the Massillon coals, and if that is true in that case it is probably true in the tests here made, whereby all these coals are tested under exactly the same furnace and no attention being paid to its particular characteristics.

PROF. LORD: I will simply say in regard to these samples, that as the coal was fed to the locomotive, every little while a shovel full was thrown aside in a box, and when that box was filled that became my sample, 50 or 100 pounds, and each sample got in this way was an average of what was used.

MR. WILEMAN: I would like to ask if these tests were carried on in the same engine and hauling about the same train.

PROF. LORD: Yes sir, remarkably close as far as conditions were concerned. Three tests were made.

PROF. SPERR: Were the conditions the same as the temperature?

PROF. LORD: There was no attention paid to the question of temperature. But it was done all in summer when the temperature was pretty near constant. These tests of evaporating power are no tests whatever of the actual performance of the coal under different conditions. I give them as an example of



the performance of these coal in firing a locomotive in the same locomotive and by the same fireman.

PROF. SPERR: Then it might be of no value at all as a test for a stationary boiler.

PROF. LORD: No.

PROF. SPERR: Were the tests made when it was dry or wet?

PROF. LORD: Well, I don't think that would make much difference. They were nearly constant.

PROF. SPERR: The amount of radiation would depend somewhat upon whether there was rain falling or not.

PROF. LORD: Yes, but these were made under practically the same conditions of weather, and extended over time enough to neutralize these conditions. Each test was an average of three made at different times, and which did not differ more than a fraction of a pound of evaporating power.

THE CHAIR: There is some cause which I believe we don't know. In this trial under the locomotive boiler of course we know that they raise steam there to a 150 pounds, more or less. Now if this was under a stationary boiler or any boiler where you would not have to steam higher than 75 pounds, the results may possibly be different. Now I have known this from observation, that the same coal, that is coal that will give about the same analysis or nearly so burns entirely different. There is a great difference in the burning a grate or ordinary fire. Now when that is I don't know, but I have always supposed myself that the difference was in the mechanical structure of the coal. Take a piece of coal that is full of seams, and the fire gets into it in a different shape from a coal that is solid. I believe also that, as I said before, that perhaps a test under different circumstances would give entirely a different result. There is another thing that I don't understand. I can't tell why it is in a coking coal, why it is that some coal will make a good coking coal that the analysis is nearly the same as another coal that will not coke as well or as nearly as well.

PROF. LORD: That is just such a puzzle as this.

MR. ROY: Mr. President, I think that we are under very great obligations to Prof. Lord, who never does anything for us but what it is of interest to us all and we are all wiser for it. I hope he will continue this investigation, and under the customary rule I move a vote of thanks for what he has done for us to-day.

The motion being seconded was carried.

PROF. SPERR: Mr. President, I move we adjourn.

The motion being seconded was carried.

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#### EVENING SESSION, 7 O'CLOCK P. M.

The Convention was called to order by the Chair who said:

The first thing in order will be a paper by Mr. Blower.